COSEWIC
Assessment and Update Status Report

on the

Allegheny Mountain Dusky Salamander
Desmognathus ochrophaeus

Great Lakes/St. Lawrence population
Carolinian population

in Canada

Great Lakes/St. Lawrence population – THREATENED
Carolinian population – ENDANGERED
2007

COSEWIC
COMMITTEE ON THE STATUS OF
ENDANGERED WILDLIFE
IN CANADA

COSEPAC
COMITÉ SUR LA SITUATION
DES ESPÈCES EN PÉRIL
AU CANADA

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Previous reports:

COSEWIC 2001. COSEWIC assessment and update status report on the Allegheny Mountain Dusky Salamander *Desmognathus ochrophaeus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 15 pp.

Alvo, R. and J. Bonin. 1998. COSEWIC status report on the mountain dusky salamander *Desmognathus ochrophaeus* in Canada *in* COSEWIC assessment and status report on the mountain dusky salamander *Desmognathus ochrophaeus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. 1-39 pp.

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Allegheny Mountain Dusky Salamander — Photo by David M. Green.

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COSEWIC
Assessment Summary

Assessment Summary – April 2007

Common name
Allegheny Mountain Dusky Salamander – Great Lakes/St. Lawrence population

Scientific name
Desmognathus ochrophaeus

Status
Threatened

Reason for designation
This is a small and secretive salamander, with aquatic larvae, that inhabits forested brooks, cascades, springs, or seeps where there is abundant cover in the form of crevices between stones, leaf litter, or logs. This species has a very small range of less than 100 km^2 in the Great Lakes/St. Lawrence faunal province in a single locality at the northernmost edge of the Adirondack Mountains. At this locality, the salamanders occupy some 8 to 10 streams and seeps with a total area of occupancy of under 10 km^2. All of these streams emanate from a single water source. The locality is isolated from any other population of the same species; the nearest other locality is about 90 km away in New York State. Its minute range makes this salamander highly susceptible to stochastic events, and the species would easily become endangered if major changes to its habitat were to take place. The major threats to this salamander in Great Lakes/St. Lawrence faunal province are any that could affect the water table and dry out seeps and springs in its habitat, degrade groundwater flow and quality or deplete groundwater reserves. Logging at the single water source could destroy terrestrial habitat by increasing siltation in streams and altering hydrological regimes.

Occurrence
Quebec

Status history
Designated Special Concern in April 1998. Status re-examined and designated Threatened in November 2001. In April 2007, renamed to Allegheny Mountain Dusky Salamander (Great Lakes /St. Lawrence population) and designated Threatened. Last assessment based on an update status report.

Assessment Summary – April 2007

Common name
Allegheny Mountain Dusky Salamander – Carolinian population

Scientific name
Desmognathus ochrophaeus

Status
Endangered

Reason for designation
This is a small and secretive salamander, with aquatic larvae, that inhabits forested brooks, cascades, springs, or seeps where there is abundant cover in the form of crevices between stones, leaf litter, or logs. This species' entire range in the Carolinian faunal province consists of a single, cascading stream in the Niagara Gorge, occupying no more than about 0.005 km^2. The locality is isolated from any other population of the same species, the nearest being about 22 km away in New York State. Surveys to date have located and identified some 22 individuals and indicate a total adult population that is probably fewer than 100 individuals. Its minute range makes this salamander highly susceptible to stochastic events and the species would easily and rapidly become extirpated if any change to its habitat were to take place. The major threats to this salamander in the Carolinian faunal province are any activities that could affect the water table and dry out the spring that supplies its habitat, degrade groundwater flow and quality or deplete groundwater reserves.

Occurrence
Ontario

Status history
This newly recognized population not previously assessed by COSEWIC was designated Endangered in April 2007. Last assessment based on an update status report.

COSEWIC
Executive Summary

Allegheny Mountain Dusky Salamander
Desmognathus ochrophaeus

Great Lakes/St. Lawrence population
Carolinian population

Species information

The Allegheny Mountain Dusky Salamander, *Desmognathus ochrophaeus*, is a small, slender salamander belonging to the family Plethodontidae (lungless salamanders). Mature salamanders average 70 to 100 mm in total length. Adults typically have a light stripe down their back that extends from the head to the tail. This stripe is straight-edged and varies in colour from grey, brown, tan, yellow, and orange, to red depending on age and sex. The stripe also commonly contains a row of chevron-shaped dark spots down the middle.

Distribution

Desmognathus ochrophaeus is found commonly throughout the Appalachian Mountain System of eastern North America. In Canada, the entire known distribution consists of two isolated locations along the Canada/U.S. border, one in Quebec and one in Ontario. Allegheny Mountain Dusky Salamanders were first discovered in Quebec in 1988, and are found on the north side of Covey Hill, at the northernmost edge of the Adirondack Mountains in extreme southwestern Quebec. The Quebec range is likely restricted to the northernmost edge of the Adirondack Mountains, an area of roughly 20 km (east to west) x 5 km (north to south). A second distinct Canadian population was discovered in the Niagara Gorge of southern Ontario in 1989 (Kamstra 1991), although it was not recognized as *D. ochrophaeus* until 2004. The total distribution of *D. ochrophaeus* in the Ontario site is limited to just over half a hectare.

Habitat

Desmognathus ochrophaeus is generally found within the vicinity of forested brooks, mountain cascades, springs, or seeps. It uses this habitat to forage, as well as for overwintering and brooding. Shelter is provided in wet cavities along stream edges or seeps, or under stones, leaf litter, or logs.

Biology

Desmognathus ochrophaeus is nocturnal. Salamanders remain hidden beneath cover objects during the day. They emerge at night to forage and feed on a variety of invertebrates. During the colder winter months, they hibernate in underground retreats. Mating and egg laying occurs in the fall and spring following an elaborate courtship ritual. The female lays a clutch of eggs in a moist depression and remains with the eggs until hatching. The larval stage may last up to 8 months and requires moist conditions but not necessarily a body of water.

Population sizes and trends

There are not currently adequate data to indicate sizes and trends of the two *D. ochrophaeus* populations in Canada.

Limiting factors and threats

For both Quebec and Ontario, the main threats to this species are those that could affect the water table, either through human activities or climatic variations. Fluctuations in water flow, or contamination of water sources, are likely to have large impacts. In Quebec, physical barriers (e.g., roads, cultivated fields) could compromise the species' movements. Logging at and around the Quebec locality could also pose a threat to this species by destroying terrestrial habitat, increasing siltation, and by altering hydrological regimes. In Ontario, any human activity that could alter the quantity, quality, or temperature of the water supply, or impose change to the surrounding forest habitat could be detrimental. Furthermore, because of their minute ranges, both populations are highly susceptible to stochastic environmental events.

Special significance of the species

The species has no direct economic value and little cultural significance to the Aboriginal community. However, it has intrinsic value as part of Canada's natural heritage, and is of interest to herpetologists and naturalists. Because of its secretive habits and nocturnal activity, it is unlikely to be seen by anyone other than the handful of people specifically doing research and monitoring.

Existing protection

This species is not yet designated in Quebec. It is currently on a list of species likely to be designated threatened or vulnerable (Gouvernement du Québec 2006). The species is, however, protected by the "Loi sur les espèces menacées ou vulnérables" (L.R.Q. chap. C-61.1), which prohibits buying, selling or keeping in captivity. Furthermore, Article 22 of the "Loi sur la qualité de l'environnement" (L.R.Q, chapitre Q-2) offers protection against unregulated degradation of environmental quality.

In Ontario, *D. ochrophaeus* is not currently listed as a species at risk because of its recent discovery in the province. COSSARO (Committee On the Status of Species At Risk in Ontario) recommendations for the species are currently under review.

At the federal level, the Great Lakes/St. Lawrence population of *D. ochrophaeus* at Covey Hill, Quebec, is protected under the *Species at Risk Act* (SARA) and listed as Threatened on Schedule 1. It was previously designated as Threatened (D2) by COSEWIC in 2001 because of its extremely restricted range in Canada, its increasingly isolated populations, and its susceptibility to habitat alteration.

COSEWIC HISTORY

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was created in 1977 as a result of a recommendation at the Federal-Provincial Wildlife Conference held in 1976. It arose from the need for a single, official, scientifically sound, national listing of wildlife species at risk. In 1978, COSEWIC designated its first species and produced its first list of Canadian species at risk. Species designated at meetings of the full committee are added to the list. On June 5, 2003, the *Species at Risk Act* (SARA) was proclaimed. SARA establishes COSEWIC as an advisory body ensuring that species will continue to be assessed under a rigorous and independent scientific process.

COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses the national status of wild species, subspecies, varieties, or other designatable units that are considered to be at risk in Canada. Designations are made on native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fishes, arthropods, molluscs, vascular plants, mosses, and lichens.

COSEWIC MEMBERSHIP

COSEWIC comprises members from each provincial and territorial government wildlife agency, four federal entities (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biodiversity Information Partnership, chaired by the Canadian Museum of Nature), three non-government science members and the co-chairs of the species specialist subcommittees and the Aboriginal Traditional Knowledge subcommittee. The Committee meets to consider status reports on candidate species.

DEFINITIONS

Wildlife Species	A species, subspecies, variety, or geographically or genetically distinct population of animal, plant or other organism, other than a bacterium or virus, that is wild by nature and is either native to Canada or has extended its range into Canada without human intervention and has been present in Canada for at least 50 years.
Extinct (X)	A wildlife species that no longer exists.
Extirpated (XT)	A wildlife species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A wildlife species facing imminent extirpation or extinction.
Threatened (T)	A wildlife species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.
Not at Risk (NAR)**	A wildlife species that has been evaluated and found to be not at risk of extinction given the current circumstances.
Data Deficient (DD)***	A category that applies when the available information is insufficient (a) to resolve a species' eligibility for assessment or (b) to permit an assessment of the species' risk of extinction.

* Formerly described as "Vulnerable" from 1990 to 1999, or "Rare" prior to 1990.

** Formerly described as "Not In Any Category", or "No Designation Required."

*** Formerly described as "Indeterminate" from 1994 to 1999 or "ISIBD" (insufficient scientific information on which to base a designation) prior to 1994. Definition of the (DD) category revised in 2006.

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The Canadian Wildlife Service, Environment Canada, provides full administrative and financial support to the COSEWIC Secretariat.

Update
COSEWIC Status Report

on the

Allegheny Mountain Dusky Salamander
Desmognathus ochrophaeus

Great Lakes/St. Lawrence population
Carolinian population

in Canada

2007

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SPECIES INFORMATION

Name and classification

The Allegheny Mountain Dusky Salamander, *Desmognathus ochrophaeus*, is a member of the Family Plethodontidae (lungless salamanders) (Order Urodela) (Fig. 1). This is the only Canadian species within the *D. ochrophaeus* complex, which consists of six morphologically and ecologically similar species: *D. apalachicolae, D. carolinensis, D. imitator, D. ochrophaeus, D. ocoee,* and *D. orestes* (Tilley and Mahoney 1996; Petranka 1998; Anderson and Tilley 2003). These species are all very closely related and are best identified by geographic range and genetic comparison. *Desmognathus ochrophaeus* is the least variable member of the complex with respect to genetic and morphological features, and is believed to have been derived from a southern form that underwent a rapid northern range expansion following the Pleistocene glacial period (Petranka 1998).

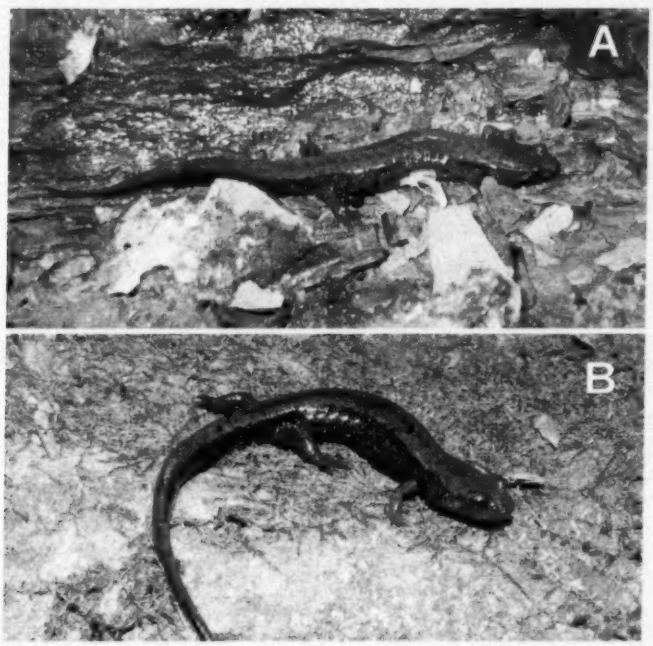

Figure 1. *Desmognathus ochrophaeus*, A. Individual from the Niagara population. Photo by Rob Tervo. B. Individual from the Covey Hill population. Photo by David M. Green.

Morphological description

Desmognathus ochrophaeus is a small, slender salamander with 14 costal grooves (Fig. 1). Mature *D. ochrophaeus* average 37 mm snout-vent length (svl) (range: 29-45 mm), or 70 to 100 mm in total length (Orr 1989; Conant and Collins 1998; Petranka 1998). Males are 6-20% longer in snout-vent length than females, and have

well-developed premaxillary teeth, larger jaw muscles, smaller mental glands, and a mouth line that appears sinuate when viewed from the side (Orr 1989; Bruce 1993).

Over its global range (Fig. 2), this species exhibits a high degree of morphological variability (Fitzpatrick 1973; Petranka 1998). Mature individuals usually have a light mid-dorsal stripe that extends from the head to the tail. This stripe is straight-edged, and its colour varies from gray, brown, tan, yellow, orange, to red, depending on age and sex. Juveniles and young adults typically have yellowish or reddish dorsal stripes. Older individuals tend to become melanistic with age and the dorsal stripe and chevron pattern become less apparent. Commonly the stripe has a mid-dorsal row of chevron-shaped dark spots. Dark pigment borders the stripe and extends laterally and ventrally to the mottled lower sides. The belly becomes light grey to grayish black with age (Petranka 1998). Larvae have prominent yolk reserves in the belly region, well-developed gills, and a well-developed fin on the dorsal and ventral surfaces of the tail (Organ 1961).

Figure 2. Global Distribution of *Desmognathus ochrophaeus*. Arrows indicate Canadian populations at Covey Hill in Quebec and Niagara in Ontario.

Individuals with a very light dorsal band are sometimes confused with the Northern Two-lined Salamander (*Eurycea bislineata*), but that species' compressed tail and yellow underparts should distinguish it. Occasionally a specimen is found that has a striking superficial resemblance to some colour phase of the Red-backed Salamander (*Plethodon cinereus*), but the comparatively larger hind legs and the light bar from the eyes to the angle of the jaw in *D. ochrophaeus* distinguish it, even in juveniles (Bishop 1941; Orr 1989).

Desmognathus ochrophaeus is most easily confused with the Northern Dusky Salamander (*Desmognathus fuscus*), which is a more stocky, less terrestrial species often found in similar habitats (Orr 1989). *Desmognathus ochrophaeus* is a montane species whose global range is contained within the range of *D. fuscus*, which is primarily a lower elevation form (Houck and Francillon-Vieillot 1988). Both species are commonly found in the same type of habitat, and the overlapping ranges of these two species, their high degree of intraspecific variation, and their propensity for hybridization (Karlin and Guttman 1981; Sharbel *et al.* 1995), have presented difficulties for field identification in regions of sympatry. Molecular analysis has therefore become necessary for the identification of species, especially within hybrid zones (Sharbel and Bonin 1992; Tilley and Mahoney 1996; Tilley 1997). Nevertheless, morphological characters can often be used with some success. Both species have an eye stripe extending from the eye to the angle of the jaws, a characteristic of all the species in the genus (Orr 1989). *Desmognathus ochrophaeus*, however, usually has a round slender tail, whereas that of *D. fuscus* is larger in diameter at the base and is keeled with a sharp crest along the dorsal edge (Bider and Matte 1996). Both species have a mid-dorsal stripe, but in *D. fuscus* the stripe usually has irregular edges rather than regular ones and *D. fuscus* lacks the chevron-shaped markings on the dorsum. Larvae of *D. ochrophaeus* have a broad, light, dorsal band that is entirely lacking in *D. fuscus* (Bishop 1941; Logier 1952).

Genetic description

Both Canadian populations of *D. ochrophaeus* are found adjacent to the Canadian/U.S. border, but are geographically isolated by distance or physical barriers from neighbouring populations in the United States. It is not known how long populations on either side of the border have been separated.

The Covey Hill population in Quebec is found approximately 90 km north of the nearest population in upper New York State. Sharbel and Bonin (1992) used allozyme electrophoresis to identify *D. ochrophaeus* and found low levels of hybridization between *D. ochrophaeus* and the closely related *D. fuscus* in southern Quebec. Hybrids can be distinguished from pure parent *D. ochrophaeus* or *D. fuscus* through molecular analysis and occasionally morphological features. Their mix of identifying characteristics, however, can make them difficult to identify in the field (Bonin 1993; Sharbel *et al.* 1995; Boutin 2006). A genetic study of the population by Boutin (2006) using a 500 base pair fragment of the 12S rRNA mitochondria gene, nuclear (RAG-1 region) DNA, and restriction enzymes also identified low levels of hybridization. Backcrossing of hybrids,

where hybrids mate with a pure parental type, has further complicated morphological identifications, and considerable backcrossing with *D. ochrophaeus* is apparent in most suspected hybrids (Sharbel *et. al.* 1995; Boutin 2006). While hybridization between pure forms of the two species remains infrequent, it is unknown what percentage of seemingly "pure" *D. ochrophaeus* contain *D. fuscus* genes. The Quebec population is believed to exist as a relatively small, genetically isolated, inbred unit with a small percentage occasionally interbreeding with *D. fuscus* (Sharbel *et al.* 1995). No genetic comparisons have been made between the Quebec population and populations south of the border, so levels of genetic differentiation are unknown.

In Ontario, Canadian populations of *D. ochrophaeus* are separated from neighbouring American populations by the Niagara Gorge and a small geographic distance. Rivers are known to impede salamander dispersal (Howard *et al.* 1983; Bonnett and Chippindale 2004), and the fast-flowing Niagara River that runs through the gorge is likely a significant barrier to gene flow. No populations are known from within the Niagara gorge on the New York side. The closest known population is located 22 kilometres east of the Canadian Niagara population along the Niagara Escarpment in New York State.

In the fall of 2005, a molecular study was undertaken to compare samples in the Niagara Gorge of Ontario with six neighbouring populations from across western New York State (Markle and Green 2006). The objective of the study was to determine if the Niagara population was genetically distinct from neighbouring U.S. populations. The analysis compared variable regions of two mitochondrial genes (cyt b and 12S rRNA) for a total sequence length of 954 base pairs. Results of the analysis did not reveal any genetic variation between any of the populations. Other studies based on allozymes have also found low genetic variation between populations of *D. ochrophaeus*, even over distances of 1000 km (Tilley and Mahoney 1996; Tilley 1997).

A total of 22 individuals from the Niagara site have now been identified through molecular analysis as *D. ochrophaeus*, suggesting that the entire population is *D. ochrophaeus*. So far, no variation has been found within the Ontario population (using mitochondrial markers cyt b and 12S rRNA) (Markle 2006 unpubl. data).

DISTRIBUTION

Global range

The global range of *D. ochrophaeus* is centred on the western slope of the Appalachian Mountain system in Eastern North America (Fig. 2) (Conant and Collins 1998; Petranka 1998). The distribution extends from the Adirondack Mountains of northern New York state, west to northeastern Ohio, and south through all of Pennsylvania except the southeastern quarter, northeastern Maryland, eastern and southwestern Virginia to eastern Kentucky, extreme western Virginia, south through the southern Blue Ridge Physiographic Section of eastern Tennessee, and western North

Carolina to northern Georgia (Orr 1989; Conant and Collins 1998; Petranka 1998). In the northern part of its range, the species is apparently absent from Vermont and eastward; the only record for Vermont is questionable (M. Ferguson, Vermont Nongame and Natural Heritage Program, pers. comm.).

Canadian range

Desmognathus ochrophaeus is widely distributed in eastern North America but reaches the limit of its range at the Canadian border. *D. ochrophaeus* was first found in Canada at Covey Hill, Quebec in 1988, but the species' identification was confirmed genetically, using isozyme electrophoresis, only in 1990 (Sharbel and Bonin 1992). An old record from the St. John River, New Brunswick (Logier 1952), was based on a misidentification (F. Cook, pers. comm.). *Desmognathus ochrophaeus* occurs in Quebec only in forested habitat on the north side of the hill known as Covey Hill (Fig. 3), at the northernmost edge of the Adirondack Mountains in extreme southwestern Quebec (45°02'N, 73°47'E) (Sharbel and Bonin 1992). There is also a town in the area called Covey Hill, but throughout this report the term "Covey Hill" will refer to the hill unless otherwise noted. The area is situated almost directly south of Montréal and about 2-4 km north of the New York border. The Quebec distribution consists of 5 to 7 springs located roughly in a rectangle 3 km x 6 km encompassing the north side of Covey Hill, plus one site located 20 km farther west near the Mitchell brook at Franklin. Covey Hill is considered as one locality with a surface area of less than 50 km² and a potential species' distribution of 100 km² (Alvo and Bonin 2003).

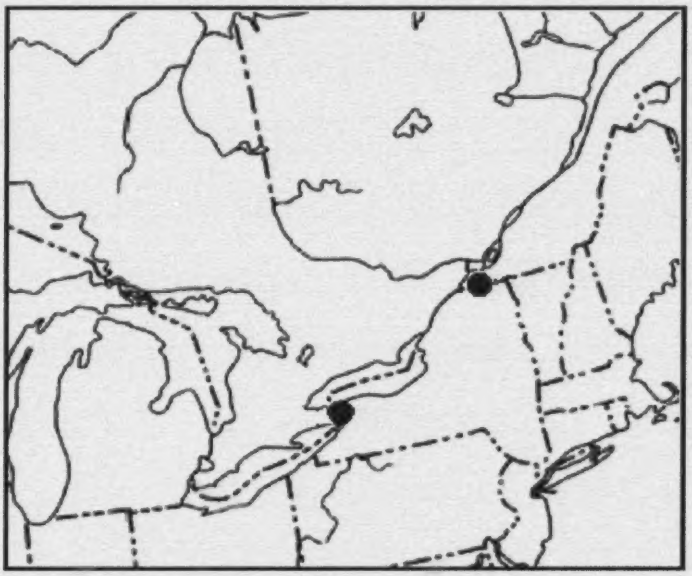

Figure 3. Canadian distribution of *Desmognathus ochrophaeus* in Niagara area, Ontario and Covey Hill, Quebec (indicated by black circles).

Covey Hill is a geological sandstone formation which forms the Piedmont section of the Adirondacks (Alvo and Bonin 2003). The area is within the Appalachians' division of Quebec and is a region of hardwood forest within the Canadian Mixedwood Plain Ecozone. Water from Covey Hill descends from the northernmost slopes of the Adirondack Mountains and flows into the St. Lawrence Valley, a region inhospitable to the species. Because the species broods and overwinters in high-elevation habitats, it is unlikely that populations will be found farther north of Covey Hill. Surveys conducted to the south of the known Covey Hill localities as far as the New York border have failed to yield the species (Bonin 1993). Sampling of stream salamanders has been carried out in potential habitat in other parts of the Piedmont, but was restricted to permanent streams and was therefore not appropriate for finding *D. ochrophaeus*. Sampling of appropriate habitat in the Eastern Townships, an area east of the known population and not in the Adirondacks, has thus far failed to find the species (J. Bonin, unpublished data). In view of its apparent absence from Vermont, Lake Champlain may be an eastern geographical barrier to its distribution.

In 1989 two *Desmognathus* salamander populations were found in the Niagara Gorge of Ontario (Kamstra 1991) and were both identified as Northern Dusky Salamanders (*D. fuscus*) based on their morphological features. A survey of these salamander populations by the Ontario Ministry of Natural Resources in September 2004, however, revealed that one of the two populations had morphological characteristics more often associated with *D. ochrophaeus* (rounded tails, straight dorsolateral stripes, and mid-dorsal chevron markings) than *D. fuscus*. Molecular analysis of tissue samples from three individuals in the population confirmed that they are *D. ochrophaeus* (Markle and Green 2005). This represents the first recorded instance of *D. ochrophaeus* in Ontario, and the only known population of this species within the province. Recent investigation of the 1989 Queenston site voucher, currently stored at the Royal Ontario Museum (ROM # 19813), has revealed that the specimen appears to be *D. ochrophaeus* based on morphological characteristics. It was originally misidentified as *D. fuscus* as reported by Kamstra (1991) (W. Weller and R. MacCulloch pers. comm.). A second voucher collected by Kamstra in 1989 is stored at the Canadian Museum of Nature (CMN # 31985) and remains identified as *D. fuscus*. Molecular analysis to confirm species type of either voucher is not possible due to preservation methods. The identity of the other population of *Desmognathus* salamanders within the Niagara Gorge (closer to Niagara Falls) was confirmed as *D. fuscus* based on molecular analysis (T. Markle unpubl. data).

The Ontario population is also within the Mixedwood Plain Ecozone and is located in an area of the Niagara Gorge north of Niagara Falls near Queenston (43°00'N, 79°00'E). The region is composed of deciduous forest (predominantly Sugar Maple, *Acer saccharum*) and is an extension of Carolinian forest, which acts as the extreme northern limit of many species whose central origins lie in the Carolinas of the United States. It is possible that the potential habitat of *D. ochrophaeus* within Ontario is restricted to moist gorge seep-type habitat along the Niagara River and Escarpment within Carolinian Forest habitat. The Niagara Gorge is a unique geographic area with many exposed geologic features caused by frequent erosion events over thousands of years. The entire

distribution of the Niagara population occurs in only approximately 0.53 ha (= 0.0053 km^2), and the whole population is found within the vicinity of a single cascade channel on a 77% slope gradient. The known distribution of this population is bordered by the Niagara River at the bottom of the gorge, and human development along the top of the cliff.

The range of this species in Canada is very restricted and represents only a very small portion of its entire global range (<1% of total distribution is in Canada). The Covey Hill and Niagara Gorge populations remain the only known populations of this species within Quebec and Ontario, respectively, despite numerous field surveys for stream salamanders conducted throughout both provinces (Weller 1977; Gordon 1979; Bonin 1989; Shaffer and Bachand 1989; Bider and Matte 1996; J. Bonin, pers. obs.; R. Tervo, pers. comm.). This species is not known to occur in any provincial parks or in any areas managed by the federal government (P. Achuff pers. comm.).

Designatable units

The two known localities for *D. ochrophaeus* in Canada are each completely isolated from other parts of the species' range. The Niagara gorge locality lies with in the Carolinian faunal province. The closest neighbouring populations are in the United States and are located along the Niagara Escarpment in New York State, 22 kilometres east across the gorge. No populations are currently known from within the Niagara Gorge on the New York side (A. Breisch pers. comm.). The Covey Hill locality is in the Great Lakes/St. Lawrence faunal province. It is approximately 90 km north of the closest known localities in upper New York State. Both localities face similar threats.

HABITAT

Habitat requirements

Members of the genus *Desmognathus* are found most commonly in or near forested brooks, rills, mountain cascades, springs, or seeps, but are usually absent from large streams where predatory fish occur (Conant and Collins 1998). Boutin (2006) characterized important habitat variables associated with *D. ochrophaeus.* The study found that small, cool, shallow streams with intermittent water flow, deep underground water reserves, large rocks, lower water temperature, narrow stream width, and high amounts of organic matter or moss were positively associated with the presence of *D. ochrophaeus.* These variables were able to help detect where salamanders were present, but varied widely depending on the time of year. *Desmognathus ochrophaeus* occupies a broad range of habitat types and therefore co-occurs with other salamanders, both terrestrial and semi-aquatic (Tipton-Jones 1994). Within its Canadian range, *D. ochrophaeus* may be found within the same vicinity as the Northern Two-lined Salamander (*Eurycea bislineata*), the Northern Dusky Salamander (*Desmognathus fuscus)*, the Northern Spring Salamander (*Gyrinophilus porphyriticus)* and the Eastern Red-backed Salamander.

Desmognathus ochrophaeus broods its eggs and overwinters in woodland springs, seeps, wet rock faces, and moist areas at higher elevations (Bishop 1941). When

nesting near streams, this species typically uses sites within the banks (Organ 1961). In New York, prior to winter, these salamanders congregate, and presumably hibernate in great numbers in springs, streams, and soggy areas, not actually in the water, but along the edges beneath stones, old logs, moss and leaves, where the ground beneath is saturated (Bishop 1941; Organ 1961). During freezing periods, this species is also known to move vertically in the ground to depths of 90 cm and will stay underground just above ground water levels (Hairston 1949). During the warmer months, *D. ochrophaeus* can be quite terrestrial, and may often be found under logs, bark and stones in forested habitat far from water.

The ability of D. ochrophaeus larvae to survive in very intermittent seepages and streams, in which *D. fuscus*, *E. bislineata* and *G. porphyriticus* larvae cannot survive, must limit competition and predation by reducing the frequency of encounters. Differential use of habitat between adult *D. ochrophaeus* adults and larvae would also act to decrease competition within the species (Krzysik 1979). Because hydrologic conditions vary from year to year, *D. ochrophaeus* may be displaced in some areas by the arrival of the other species during wet years, and probably recolonizes these sites during dry years. If this is so, it would be important to conserve an area in which this species could move between several "oases" with varying hydrological regimes – this would require protection of the oases and the areas between them, or at least the important corridors (Bonin 1993).

Habitat trends

Desmognathus ochrophaeus occurs in sites in Quebec that were cultivated in the past. The population has maintained itself despite the fact that the flow characteristics of at least some local streams have probably undergone changes resulting from the loss and subsequent regrowth of forest cover (Bonin 1993; Sharbel *et al.* 1995), and variation in annual rainfall (Bonin 1994). Logging in the Covey Hill area probably commenced in the 1830s, largely to clear the land for farming. Cattle had access to much of the area, even within the remaining forests. In the mid-1900s, many of these farms were abandoned, and secondary growth replaced much of the cleared area (Bonin 1994; pers. data).

The amount of water being used by homes and farms is not currently a threat to the water table. Although the existing orchards and a single campsite probably use considerable amounts of water, they are situated largely in low-lying areas rather than in the headwater areas used by the salamander. Nevertheless, a general shift is occurring in the area, from agriculture to tourism and residences: a campground was created downhill from one of the known sites, and numerous cottages have been built uphill. In 1990, a golf course was planned for the area uphill, but no decision has been made yet. Thus, although current pressure on the water table by the local human population is minimal, this could change if a large industry, residential development or golf course were erected on the hill (Barrington *et al.* 1993). In North Carolina, the species has been observed to use the edges of mountain roads where the rock has been dynamited and from which water oozes. Some habitats have thus been created by humans (Huheey and Brandon 1973). However,

this phenomenon has not been observed in Quebec. No new habitat for this species is likely to arise outside the 100 km² potential area near Covey Hill in Quebec, as the species requires high-elevation habitats and neighbouring regions are inhospitable.

The Niagara area of Ontario has also undergone considerable development in the last couple of centuries, leaving much of the potential habitat fragmented or unsuitable. This species depends on seepage areas or streams draining from elevational heights, leaving suitable habitat restricted to the Niagara gorge and potentially the Niagara Escarpment. As there is only a single location known in Ontario, this would indicate that there is either poor dispersal between suitable habitat sites, or that this species had very specific microhabitat requirements. The stream being currently used by the Niagara population emerges from below the gorge crest. Slumping of seepage areas and landslides may have the potential to create new habitat, but also have the potential to destroy the single cascade that the Ontario population is known to use. Certain areas of habitat between the *D. ochrophaeus* and *D. fuscus* populations within the gorge are already unsuitable as the result of human development. The Niagara Escarpment is a natural fault feature stretching from Niagara Falls to Tobermory in southern Ontario. The Niagara population, however, is separated from the escarpment by the Niagara Parkway Road, and it is unknown how much of the escarpment may provide suitable habitat. Stream salamander surveys to date have not uncovered *D. ochrophaeus* along any section of the Niagara Escarpment in Ontario, although it is readily found along the escarpment in New York State (R. Tervo pers. comm.).

Habitat protection/ownership

In Quebec, all the land with potential habitat for this species is under private ownership, with roughly 100 landowners involved. No steps are currently underway to acquire habitat for this species. However, the Nature Conservancy of Canada, a private conservation organization, is currently attempting to protect a natural area roughly 2 km from the nearest *D. ochrophaeus* site (Bonin 1993). In fact, it is work on that natural area which led to the discovery of *D. ochrophaeus* in Quebec. Several landowners in the area are thus already aware of the work of the Nature Conservancy of Canada. Furthermore, a presentation has been given to local citizens on the existence of the rare salamanders in the area. Habitat acquisition by itself would not guarantee protection of this species on Covey Hill. Water planning for the whole area should take into account this species' requirements, and this would have to be done in conjunction with the municipality, local residents and landowners (Bonin 1993).

In Ontario, the entire Niagara population is found in parkland that is part of the Niagara Parks system, which is managed by the Niagara Parks Commission, an agency of the Government of Ontario. The surface area where the population is found is therefore currently protected from further surface development. This does not, however, provide protection from developments in surrounding areas which may jeopardize the habitat quality and put the essential groundwater source at risk. The area is also along a very steep gorge, which makes access almost impossible from above, and very difficult from below. The location of the site decreases the likelihood of individuals disrupting the habitat.

BIOLOGY

Life cycle and reproduction

Desmognathus ochrophaeus is nocturnal. Salamanders remain hidden beneath cover objects during the day. When moisture levels are suitable, they emerge shortly after sunset and may be found foraging in the vicinity of their daytime retreats with peak surface activity shortly after dark (Bishop 1941; Holomuzki 1980).

Desmognathus ochrophaeus is a generalist feeder and eats a diverse array of terrestrial invertebrates. For the most part it seems to be largely insectivorous, taking ants, crane flies, dipteran larvae, lepidopteran larvae, homopterans, hymenoptera, spiders, mites, phalangids, millipedes, and apparently some vegetation (Bishop 1941; Petranka 1998). In Ohio, it feeds mostly on earthworms (Keen 1979), fly larvae, adult beetles, collembolans, and mites (Orr 1989). Occasionally it will prey upon *Desmognathus* larvae and eggs (Huheey and Brandon 1973; Forester 1983).

This species uses a sit-and-wait (ambush) mode of predation in a home range averaging 1.06 m^2 in seepage banks (Orr 1989). Feeding kinematics are similar to other plethodontids, where gape formation involves raising of the upper jaw while the lower one remains fixed. After the sticky tongue pad makes contact with the prey, the salamander's head surges forward and the pad is rapidly retracted as the mouth snaps shut with considerable force (Larsen and Beneski 1988).

During the winter months, feeding is reduced and *D. ochrophaeus* retreats to seepage areas and underground retreats where ground water temperatures remain relatively constant throughout the winter. At this time, fat bodies have developed to their maximum. The species usually becomes active again in March, at which time yolking of the eggs is complete (Orr 1989). Hibernation typically begins in November in southern parts of the range. In Quebec, the hibernation period is presumably longer, starting earlier in autumn and ending later in spring. However, salamanders are known to leave their winter retreats any time that temperatures are favourable (Petranka 1998).

Mating and egg-laying take place both in the fall and spring in New York State, and presumably in neighbouring Canadian populations (Bishop 1941). Males search for and find females using vision and smell (Uzendoski and Verrell 1993; Evans and Forester 1996). When a male finds a female, he places his snout on her back. This is followed by a fairly elaborate courtship involving a stereotypical tail-straddle walk characteristic of all *Desmognathus* species (Houck *et al.* 1985; Mead and Verrell 2002). Eventually a spermatophore is deposited followed by forward movement of the courting pair to position the vent of the female over the spermatophore. The female picks up the sperm cap using her cloacal lip and the cap is withdrawn into the female's cloaca usually over a period of 2-3 hours (Organ 1961). Physical stimulation by the presence of the sperm cap in the female's cloaca inhibits the female's sexual responsiveness to other males (Verrell 1991). In most salamander species, the females can store viable sperm in the epitheca for months, and in some cases, years (Houck and Schwenk 1984).

Male mating capacity is limited in this species, contrary to the traditional assumption for most organisms that males are able to produce large quantities of sperm. This limitation puts constraints on a male's number of inseminations (Verrell 1988). When given a choice, males select larger females which tend to have more eggs than smaller females, thus giving the male the opportunity to fertilize more eggs per insemination (Verrell 1989). Aggressive behaviour of males towards other males during the courtship season is common and seems to be an important method by which sex recognition occurs in all species of *Desmognathus* (Organ 1961).

Females are thought to seek nest sites far in advance of laying their eggs and return to the same nest site year after year (Bider and Matte 1996). In comparison to other members of the complex, *D. ochrophaeus* appears to have a stronger tendency to nest underground (Keen and Orr 1980). Oviposition typically occurs in mud crevices and depressions beneath logs and stumps that are embedded in mud or hillside seeps and springs. Clutch size is positively correlated with snout-vent length and varies from 11 to 14 eggs in New York (Bishop 1941), and 8 to 24 in Pennsylvania (Hall 1977), and in some case up to 40 eggs per female (Verrell 1989). Typically, the eggs are deposited in a cluster, the outermost envelope of the individual eggs being drawn out and attached to a common stalk so that the mass looks like a small bunch of grapes. The mass is attached to the lower surface of the object that serves as cover for the nest. Mature ova measure 2.5-3.0 mm in diameter and well-developed embryos are about 4 mm in diameter (Bishop 1941; Logier 1952; Keen and Orr 1980).

Males do not provide courtship feeding, nest sites, or parental care (Houck *et al.* 1985). Females, however, apparently remain with their eggs throughout the entire development of the embryos and through hatching. It seems that they do not leave the eggs to forage but may feed on small organisms that enter the nest cavity. The attending females are usually found in the nest coiled around the egg mass, the chin resting upon it or the head thrust into the centre of the mass (Organ 1961). Most females lose weight over the brooding season, using up an estimated 16% of their annual energy budget (Fitzpatrick 1973). The brooding female contributes to the survivorship of her eggs not only by defending them from predators, but also by eating infected eggs. This action halts the spread of fungal infestations in the clutch, increases oxygenation, reduces the yolk layering of the eggs through mechanical stimulation of the eggs, and lowers the rate of egg desiccation by reducing the exposed surface of the egg mass (Tilley 1972; Forester 1979; Forester 1984; Orr 1989). Females can specifically recognize, and will preferentially brood, their own eggs over those of a conspecific (Masters and Forester 1995).

Hatching has been found to occur in March, September, and October in New York (Bishop 1941). Newly hatched larvae average 13-18 mm in total length (Petranka 1998). They have prominent yolk reserves in the belly region, well-developed gills, and a well-developed fin on the dorsal and ventral surfaces of the tail (Organ 1961). The gills are retained for a few days to several weeks, and this is apparently determined largely by the amount of moisture present, and to some extent by temperature. Nevertheless, larvae do not have to enter water to survive. Unlike many other species of salamanders,

larval development only requires wet media and may include rock faces near seepages, mossy or muddy areas that are continually moist, or very shallow surface water. During this period, larvae feed on small invertebrates. The larval period can last anywhere from 2-3 weeks upwards to 8 months (Keen and Orr 1980). When larvae transform into juveniles, they are approximately 18 mm in total length. Larvae that experience high temperature and/or high food regimes grow faster and metamorphose earlier than larvae on low-temperature and low-food regimes (Bernardo 1994; Beachy 1995).

Sexual maturity is usually attained at the end of the second year or at the beginning of the third for males when they reach a snout-vent length of at least 30 mm (Bishop 1941; Logier 1952). Females typically reach sexual maturity one year later than males at 3 or 4 years of age, or once they have reached 30-34 mm in snout-vent length (Organ 1961; Petranka 1998). While males reach sexual maturity at a smaller size, they surpass females in body size as they age. This may be because in older individuals the rate of increase in reproductive success with body size is probably greater in males than in females (Bruce 1993). Desroches and Rodrigue (2004) report average longevity at seven years, although the upper limit may reach 15 years (Orr 1989).

Predation

Adults, larvae, and eggs of this species may be taken by snakes, crayfish, small mammals and birds, and by other salamanders. The Short-tailed Shrew (*Blarina brevicauda*) whose burrows are occupied by a large variety of salamanders (Brodie *et al.* 1979) is a known predator, as are racoons, opossums and skunks. Avian predators include Hermit Thrushes (*Catharus guttatus*) that uncover salamanders during diurnal foraging (Bishop 1941; Forester 1978; Brodie and Brodie 1980; Hom 1988; Orr 1989; Whiteman and Wissinger 1991). Co-occurring Spring Salamanders, *Gyrinophilus porphyriticus*, are known to be common predators of *D. ochrophaeus* (Formanowicz and Brodie 1993; Uzendoski *et al.* 1993; Hileman and Brodie 1994).

Desmognathus ochrophaeus, like others of its genus, lacks noxious skin secretions that appear to function as an antipredator adaptation in salamanders of many other genera (Brodie 1977). *Desmognathus ochrophaeus* therefore have a higher potential to suffer from predation than other plethodontid salamanders. However, in some populations it appears to use mimicry of distasteful salamander species to reduce predation (Brodie and Howard 1973).

Predator-induced autotomy (self-amputation) of the tail also seems to be an effective anti-predator strategy. When seized by a predator, the twitching automized tail appears to function in directing the attention of the predator to the tail and away from the salamander. Although tail loss and its regeneration are energetically expensive, and reduce the reproductive output of some plethodontid salamanders, it does not seem to interfere with courtship and insemination success in males (Orr 1989). To make themselves less conspicuous to predators, individuals may also remain immobile when uncovered (Dodd 1990). They also avoid chemical cues from wounded conspecifics, and from predators such as snakes, which may further help them to reduce predation risk

(Cupp 1994; Luttershmidt *et al.* 1994). When disturbed these salamanders often try to flee by running or through violent lateral contortions involving the body and tail (Bishop 1941), and when attacked may bite the predator (Formanowicz and Brodie 1993).

Physiology

Plethodontid salamanders lack lungs and therefore rely on cutaneous and buccal respiration for gas exchange (Desroches and Rodrigue 2004). An important consequence is that the skin must be moist and permeable for gas exchange to occur, and this restricts plethodontids to moist microhabitats. Even in moist terrestrial habitats, plethodontids lose water when outside retreats or burrows (Feder 1983). The rate of dehydration depends on body size, relative air humidity, and ambient temperature, with dehydration being more rapid in small individuals, under conditions of lower relative humidity, and at high temperatures (Spotila 1972).

Water loss may restrict foraging and courtship on all but very wet nights, and surface activity may be abandoned during dry periods. Thus the lives of plethodontids may consist of long periods of inactivity interspersed with brief periods of activity when thermal and hydric conditions permit. Key specializations (low metabolic rate, large energy stores, profound resistance to starvation) may enable them to survive indefinite periods between unpredictable bouts of feeding (Feder 1983; Feder and Londos 1984). *Desmognathus ochrophaeus* is less active and ingests less prey when the air temperature is low (0º-5ºC), and it remains in subterranean refugia when the minimum daily air temperature is below 0ºC (Keen 1979).

Dispersal/migration

The movements of *D. ochrophaeus* in Canada are not well known. *Desmognathus ochrophaeus* has the ability to disperse either across land or along waterways, but is not believed to typically be a long distance disperser. This species is, however, the most terrestrial of the Dusky Salamanders and actively disperses up to 75 m from open water in the summer (Bishop 1941; Organ 1961). In rock faces in North Carolina, individuals averaged 40-45 cm in movements between successive captures and appeared to have a limited range (Huheey and Brandon 1973). In Ohio, mean home range for individuals was less than 1 m^2, although a minimum of 25% of individuals returned home after being displaced 30 m (Holomuzki 1982). In North Carolina, in optimal habitat, some females occurred as close as 4 cm to each other. Reproductive effort by a given female tends to occur in the same 5 m segment of stream during successive years; this likely indicated that gravid females home from nearby terrestrial habitats to a "preferred" or "previously known" stream segment during the reproductive season (Forester 1977). The extent to which adults establish and defend territories remains poorly understood.

The Yellow Spotted Salamander (*Ambystoma maculatum)* and the Blue-Spotted Salamander (*Ambystoma laterale*) are killed annually in large numbers by vehicles in eastern Canada during their relatively long-distance migrations (R. Alvo and J. Bonin, pers. obs.). For *D. ochrophaeus*, however, the very small home ranges that have been

observed in the U.S. suggest that very few, if any, get killed on roads, and overall movement may be quite limited.

Interspecific interactions

Habitat type and the presence of larger predatory species affect movement and resource use in stream salamander communities. In Quebec, *Gyrinophilus porphyriticus* could potentially affect the presence of *D. ochrophaeus* because it is considerably larger and preys upon *D. ochrophaeus*. Where *D. fuscus* is present, *D. ochrophaeus* is known to move away from surface water to drier, less desirable substrates (Krzysik 1979). It has been hypothesized that interspecific competition may have been a driving factor behind the evolution of body size and terrestrialism within the genus *Desmognathus* (Krzysik 1979).

Desmognathine populations vary in size as a function of the abundance of other salamander species in the habitat, because of competition and predation (Southerland 1986; Roudebush and Taylor 1987). This is suggested by the absence of *D. ochrophaeus* from the more permanent streams containing *D. fuscus* in Quebec (Bonin 1993), and by the results of other ecological studies on *Desmognathus* salamanders (Hairston 1949, 1980).

Adaptability

Desmognathus ochrophaeus differs relative to other *Desmognathus* species in its greater tolerance to water loss, which enables it to travel long distances from permanent water sources (Houck and Bellis 1972). This may alleviate hunting pressure on prey in stream habitats, and reduce intra/interspecific competition. Other key specializations, including low metabolic rate, large energy stores, and resistance to starvation, allow *D. ochrophaeus* to survive long periods without feeding (Feder 1983; Feder and Londos 1984).

Larvae of *D. ochrophaeus* are specially adapted to survive in very intermittent seepages or in areas containing only a small amount of surface moisture. This ability may enable *D. ochrophaeus* to escape predation and competition by larger stream salamanders that require more permanent water sources for larval development.

POPULATION SIZES AND TRENDS

Search effort

Desmognathus ochrophaeus was only recently confirmed to occur in Canada. This is not because the Canadian localities were unknown. The species is easily mistaken for *D. fuscus* and it was not reported simply because its presence was not suspected. This is true of specimens from both Covey Hill and the Niagara Gorge prior to the genetic confirmation of their identity (Sharbel and Bonin, 1992; Markle and Green,

2005). There has been considerable search effort made for this species subsequent to its recognition, especially in Quebec (Boutin 2003, 2006; Jutras 2003). Studies of the population in Ontario are only just beginning. Surveys up to this point have been to verify the presence of the species, to get an indication of its habitat, and to try and determine the potential extent of its distribution (R. Tervo, pers. comm).

Abundance

The size of the Canadian population is difficult to estimate. Because the seepages and temporary streams that these salamanders inhabit are not mapped on topographic charts or even air photos, the abundance of *D. ochrophaeus* is difficult to quantify without surveying the whole area by foot. In Quebec, the majority of the habitat is privately owned by several owners, making field surveys more complicated. In Ontario, the population exists in a very steep and treacherous section of the Niagara Gorge, which also makes population estimates difficult.

At Covey Hill, approximately 120 individual *D. ochrophaeus* plus about 12 hybrids (*D. ochrophaeus* x *D. fuscus*) were found in 5 temporary streams and 2 seepages in the early 1990s. In July 2003, a stream salamander inventory was conducted in three sectors of Covey Hill in a joint project between the University of Montréal, the Quebec provincial government and non-government societies (Boutin 2003). The study was carried out to gather information on the distribution and abundance of Quebec's four species of stream salamanders and to determine the presence and frequency of hybrids of *D. ochrophaeus* and *D. fuscus*. While abundances remain unknown, 97 *D. ochrophaeus* were found recently in the Covey Hill area over a five month period consisting of 36 days of sampling (Boutin 2006).

In Quebec, salamander densities were measured in three temporary streams. Densities (not including hybrids) varied from 0.67 to 1.19 individuals/m of stream with hybrids representing less than 10% of the total (Bonin 1993; Sharbel *et al.* 1995). Only a portion of the salamanders present are found during surveys, however, as individuals may be underground or in inaccessible crevices. Determination of the actual density would require capture-recapture studies and/or more exhaustive (and likely destructive) survey methods. These densities, though, are comparable to the 0.96 - 1.20 animals/m^2 estimated by Orr (1989) in Ohio and the 0.62 - 1.07 animals/m^2 estimated by Hall (1977) in Pennsylvania. However, population densities of this species in favourable rock face habitats in North Carolina are known to be as high as 25 animals/m^2 (Huheey and Brandon 1973).

In the single cascading stream in the Niagara Gorge in which it occurs, the total number of *Desmognathus ochrophaeus* so far identified by molecular analysis is 22. Determination of the actual abundance of this population would require capture-recapture studies and potentially destructive survey methods. Eggs and juveniles have been located at the site, indicating that successful reproduction is occurring (R. Tervo pers. comm.).

Fluctuations and trends

It is not possible to determine population trends as insufficient data have been collected to allow an estimation.

Rescue effect

The range of *D. ochrophaeus* only just crosses the border into Canada. While the distribution in the United States is large and continuous, both Canadian populations are separated from populations south of the border by physical barriers, such as the Niagara River, or by distance (>90km). The distances and physical barriers individuals would need to overcome to reach Canada make it unlikely that gene flow is presently occurring, and the potential for natural immigration is extremely low. As a result, there is little rescue potential for Canadian populations in the event of a decline or extirpation.

LIMITING FACTORS AND THREATS

Limiting factors and threats facing both Canadian populations are likely to be similar to each other and to *D. ochrophaeus* elsewhere. Human activities that could modify the habitat of this species, especially anything that can affect the quality, abundance, or temperature of ground and surface water or damage forest habitat, would likely be detrimental to the survival of these populations. The major limiting factors for this species, in order of decreasing importance, are factors affecting underground water reserves, microhabitat features, and movement. Furthermore, because of their minute ranges, both populations are highly susceptible to stochastic environmental events.

Underground water reserves feed seeps and springs inhabited by *D. ochrophaeus*, and are essential in providing brooding, feeding, and overwintering habitat in both Quebec and Ontario. In Covey Hill, the nature of the rock and the presence of a large peat marsh at the top of the hill serves as an important reservoir that feeds the water table (Barrington *et al.* 1993). Water extraction for residential developments or campgrounds, resorts, golf courses, and large industries would decrease the amount of water available to sustain the salamander's habitat, and would likely have detrimental impacts (Barrington *et al.* 1993; Jutras 2003; Desroches and Rodrigue 2004). Project ideas for groundwater exploitation for both commercial and industrial use are being proposed on a regular basis. Recently, a project to pump and exploit spring water was proposed in the Franklin Area of Quebec near Covey Hill, but the proposal was withdrawn after opposition by the local community (Bonin 2001). The situation is potentially serious, as current laws do not make it possible to protect natural habitat from the effects of such exploitations. The situation is further complicated, as ground water is shared across the border with the United States. The current quantity of groundwater used in the Covey Hill area by agricultural and private residences does not constitute a threat to groundwater levels (Alvo and Bonin 2003). A campsite facility and surrounding orchards likely use a considerable amount of water but are fortunately at a

lower altitude than where the salamanders are found. Further development on the higher part of the hill, however, or any destruction of the peat marsh, would likely change groundwater levels. Even if residential use of water supply is moderate, a large development such as a golf course could have a significant impact (Alvo and Bonin 2003).

The Niagara population faces a similar situation where current groundwater levels are adequate for salamander survival but any further major developments along adjacent lands could cause changes to the hydrologic cycle. Such changes may increase or decrease peak flows and discharge volumes from tableland areas. Any change in water flow is potentially detrimental to the Niagara population.

Both populations also have the potential to be contaminated by polluted runoff waters. At Covey Hill, the population is at a higher elevation than much of the farmland and development which may prevent contamination to some extent. Agricultural land and adjacent golf courses have the potential to contaminate groundwater sources with high levels of pesticides and fertilizers. In Niagara, runoff is more likely to flow from nearby industrial and urban areas into the gorge waterway. This is a major concern for the Niagara population, as storm discharge may contaminate water with an array of chemicals, heavy metals, oil, and other pollutants. Kucken *et al.* (1994) found that acidification and metal stream contamination caused a 50% reduction in populations of *D. ochrophaeus* compared to in reference sites. Orser and Shure (1972) found that salamander populations of the closely related *D. fuscus* were significantly affected by runoff and soil erosion resulting from urbanization in spring-fed streams near Atlanta, Georgia. Also in Ontario, levels of TDS (total dissolved solids) may be a limiting factor for *D. ochrophaeus*, as individuals are found only in a seepage area that has very high TDS (total dissolved solids) and conductivity. This is distinctive among other streams and seepage areas in the gorge which have much lower TDS and conductivity (R. Tervo unpubl. data).

Deforestation for agricultural or urban development may also have large impacts on *D. ochrophaeus* populations. Forests act as important water reservoirs, and when they are lost their absence can result in a much more variable flow of water in nearby streams (Bormann and Likens 1979; Likens 1985). Logging can alter the physico-chemical properties of the water (Martin *et al.* 1984; Likens 1985). In a western Oregon study that examined occurrence and abundance of four species of aquatic amphibians in unlogged streams and streams that had been logged 14 - 40 years prior, species richness, density and biomass were highest in streams in unlogged forests (Corn and Bury 1989). Another study on the effects of clearcutting by Knapp *et al.* (2003) found that sites with canopy removal had significantly fewer salamanders than the uncut control. The study also found that gravid female *D. ochrophaeus* weighed less in cut treatments. This difference may be significant as body weight is directly correlated with number of eggs produced, and lower weight may indicate the females were in poorer physiological condition. Deforestation can lead to soil erosion, increased sedimentation in streams, changes in light intensity, and modification or loss of habitat. Such changes are likely to affect intermittent streams which form the principal habitat of this species, and which are not protected from forest harvesting practices (Alvo and Bonin 2003;

Jutras 2003; Knapp *et al.* 2003). Sedimentation in streams following logging may block overwintering and nesting cavities of this species (Alvo and Bonin 2003). Microhabitat features that are important for plethodontid salamanders are burrows, cover objects, substrate type and vegetation type (Southerland 1986). Alteration of these natural features by residential construction, agriculture, or other human practices could limit population size. Decreased leaf litter production and an increase in temperature, through greater sun exposure, can lead to drier conditions whereby salamanders forage less effectively. Invertebrate prey may also decrease. While deforestation is likely to be a greater threat to the Quebec population, any tree removal surrounding the Niagara population could also have a negative impact.

Movements of individuals are important for interspecific interactions and to maintain metapopulation dynamics. Although the movements of this species are poorly known, landscape barriers (e.g. roads, cultivated fields, deforestation) could compromise the population through further fragmentation. The extent to which this species moves at different times of year should be studied in the Canadian range, given that movement seems to vary considerably in different contexts.

Other potential threats may include all terrain vehicle use, collecting, or human recreation in or near salamander habitat (Jutras 2003). In more permanent stream habitats, introduction of predatory fish could impact salamander populations (Bonin 2001; Jutras 2003). Although *Desmognathus ochrophaeus* and *D. fuscus* have altogether only ever been found in two sites in the Niagara Gorge, habitat destruction and changes in groundwater flow have already created unsuitable habitat in areas of the gorge between the sites. Also, as the Niagara population is only found in a single cascade channel, it is also likely to be vulnerable to natural catastrophes. Rock falls and mudslides occur frequently in the Niagara Gorge (R. Tervo pers. comm.), and have the potential to wipe out the necessary seepage habitat of this population. Distribution in both Quebec and Ontario is so limited that any further degradation or loss of habitat is likely to compromise the long-term survival of this salamander in Canada.

SPECIAL SIGNIFICANCE OF THE SPECIES

The species has no direct economic value and little cultural significance to the Aboriginal community. However, it has intrinsic value as part of Canada's natural heritage, and is of interest to herpetologists and naturalists. As the Canadian populations are isolated from neighbouring populations, and occur at the northern limit of the range, they may possess unique traits not present in American populations. Because of its secretive habits and nocturnal activity, *D. ochrophaeus* is unlikely to be seen by anyone other than the handful of people specifically doing research and monitoring.

EXISTING PROTECTION OR OTHER STATUS DESIGNATIONS

This species is not yet designated in Quebec. It is currently on a list of species likely to be designated threatened or vulnerable (Gouvernement du Québec 2006). The

species is, however, protected by the "Loi sur les espèces menacées ou vulnérables" (L.R.Q. chap. C-61.1), which prohibits buying, selling or keeping it in captivity.

Protection means have been developed for stream salamanders, including *D. ochrophaeus*, within the framework for forestry interventions in public forests and will soon to be applied to locations where the salamander is found. This provision will still have impact on private land insofar as it will affect adjacent habitats and groundwater. Furthermore, Article 22 of the "Loi sur la qualité de l'environnement" (L.R.Q, chapitre Q-2) offers protection against unregulated degradation of environmental quality. Whosoever undertakes construction or industrial activity that negatively affect a river, lake, pond, marsh, or peat bog must beforehand obtain a certificate of authorization from the minister.

In Ontario, owing to its recent discovery in the province, *D. ochrophaeus* is not listed as a species at risk on the 2006 SARO (Species at Risk in Ontario) list (see: http://www.mnr.gov.on.ca/mnr/speciesatrisk/statuslist.html). The species is being considered for listing.

At the federal level, the Great Lakes/St. Lawrence population of *D. ochrophaeus* at Covey Hill, Quebec, is protected under the Species at Risk Act (SARA) and listed as Threatened on Schedule 1. Previously, *D. ochrophaeus* was designated as Special Concern (1998) by COSEWIC based on the status report by Alvo and Bonin (1998). In 2001, the species' status was re-assessed using COSEWIC's quantitative criteria. As a result, *D. ochrophaeus* was designated Threatened (D2) due to its extremely restricted range in Canada, the isolation of its population and its susceptibility to habitat alteration.

In the United States, the range of *Desmognathus ochrophaeus* is large and continuous (Conant and Collins, 1998) and it is ranked as N5, indicating that the species is secure nationally.

TECHNICAL SUMMARY

***Desmognathus ochrophaeus* (Great Lakes/St. Lawrence Population)**
Allegheny Mountain Dusky Salamander — Salamandre sombre des montagnes
Range of Occurrence in Canada: Quebec

Extent and Area Information	
• *Extent of occurrence (EO)(km²)* **EO measured by drawing a polygon around all known sites of occurrence. Determined by Joel Bonin.**	< 50 km².
• *Specify trend in EO*	unknown
• *Are there extreme fluctuations in EO?*	unknown
• *Area of occupancy (AO) (km²)* **The area of occupancy is an estimate that includes all streams, seeps and adjacent terrestrial sites within the EO where salamanders have been found.**	< 10 km²
• *Specify trend in AO*	unknown
• *Are there extreme fluctuations in AO?*	unknown
• *Number of known or inferred current locations*	one
• *Specify trend in # locations*	none
• *Are there extreme fluctuations in number of locations?*	no
• *Specify trend in area, extent or quality of habitat*	none
Population Information	
• *Generation time (average age of parents in the population)* **Sexual maturity occurs 2-3 years for males and 3-4 years for females**	Approximately 4 yrs.
• *Number of mature individuals* **based on abundance surveys so far taken**	Unknown, probably <1,000
• *Total population trend:*	unknown
• *% decline over the last/next 10 years or 3 generations.*	unknown
• *Are there extreme fluctuations in number of mature individuals?*	unknown but possible
• *Is the total population severely fragmented?*	Yes
• *Specify trend in number of populations*	none
• Are there extreme fluctuations in number of populations?	No
• List populations with number of mature individuals in each: Covey Hill (Qc): probably <1,000	
Threats (actual or imminent threats to populations or habitats) • Changes to the quality or abundance of ground or surface water. • Deforestation for agricultural or urban development that damages or destroys terrestrial forest habitat, increasing siltation and altering hydrological regimes • contamination of ground or surface water • stochastic environmental events due to the small sizes of the populations • physical barriers such as roads and cultivated fields compromise the species' movements • all terrain vehicle use	
Rescue Effect (immigration from an outside source)	
• *Status of outside population(s)?* **USA:** *Desmognathus ochrophaeus* in the United States has a large and continuous range and is considered common with no major threats. It is ranked as N5 in the U.S., indicating that the species is secure nationally. It is secure in 7 states including New York State.	
• *Is immigration known or possible?* The Covey Hill population is >90km from the nearest US population.	No

• *Would immigrants be adapted to survive in Canada?* Populations in the U.S. are located in similar habitats and climates as those in Canada.	Yes, quite likely
• *Is there sufficient habitat for immigrants in Canada?* The Canadian range is very restricted and suitable habitats are already occupied by this species.	No
• *Is rescue from outside populations likely?*	No
Quantitative Analysis	NA
Current Status **COSEWIC: Threatened (2001, 2007)**	

Status and Reasons for Designation

Status: Threatened	**Alpha-numeric code**: D2

Reasons for Designation:

This is a small and secretive salamander, with aquatic larvae, that inhabits forested brooks, cascades, springs, or seeps where there is abundant cover in the form of crevices between stones, leaf litter, or logs. This species has a very small range of less than 100 km^2 in the Great Lakes/St. Lawrence faunal province in a single locality at the northernmost edge of the Adirondack Mountains. At this locality, the salamanders occupy some 8 to 10 streams and seeps with a total area of occupancy of under 10 km^2. All of these streams emanate from a single water source. The locality is isolated from any other population of the same species; the nearest other locality is about 90 km away in New York State. Its minute range makes this salamander highly susceptible to stochastic events and the species would easily become endangered if major changes to its habitat were to take place. The major threats to this salamander in Great Lakes/St. Lawrence faunal province are any that could affect the water table and dry out seeps and springs in its habitat, degrade groundwater flow and quality or deplete groundwater reserves. Logging at the single water source could destroy terrestrial habitat by increasing siltation in streams and altering hydrological regimes.

Applicability of Criteria

Criterion A: (Declining Total Population): Insufficient information.

Criterion B: (Small Distribution, and Decline or Fluctuation): The distribution in Canada is very small but there is insufficient information available to assess decline.

Criterion C: (Small Total Population Size and Decline): The number of individuals in Canada is likely under 1,000 adults but there is insufficient information available to assess decline.

Criterion D: (Very Small Population or Restricted Distribution): The species has a very restricted range. The sole location is highly susceptible to any changes in water quality or quantity. The species thus is capable of becoming highly endangered very rapidly.

Criterion E: (Quantitative Analysis): Not applicable.

TECHNICAL SUMMARY

***Desmognathus ochrophaeus* (Carolinian population)**
Allegheny Mountain Dusky Salamander — Salamandre sombre des montagnes
Range of Occurrence in Canada: Quebec

Extent and Area Information	
• *Extent of occurrence (EO)(km²)* **EO Determined by OMNR.**	0.0053 km².
• *Specify trend in EO*	unknown
• *Are there extreme fluctuations in EO?*	unknown
• *Area of occupancy (AO) (km²)* **The area of occupancy is an estimate that includes all stream/seep and adjacent terrestrial sites within the EO where salamanders were found.**	0.0053 km²
• *Specify trend in AO*	unknown
• *Are there extreme fluctuations in AO?*	unknown
• *Number of known or inferred current locations*	one
• *Specify trend in # locations*	none
• *Are there extreme fluctuations in number of locations?*	no
• *Specify trend in area, extent or quality of habitat*	none
Population Information	
• *Generation time (average age of parents in the population)* **Sexual maturity occurs at 2-3 years for males and 3-4 years for females**	Approximately 4 yrs.
• *Number of mature individuals* **based on abundance surveys so far taken. A total of 22 individuals have been identifed**	<100
• *Total population trend:*	unknown
• *% decline over the last/next 10 years or 3 generations.*	unknown
• *Are there extreme fluctuations in number of mature individuals?*	unknown but possible
• *Is the total population severely fragmented?*	Yes
• *Specify trend in number of populations*	none
• Are there extreme fluctuations in number of populations?	No
• List populations with number of mature individuals in each: Niagara Gorge (Ont): <100	
Threats (actual or imminent threats to populations or habitats) • Changes to the quality or abundance of ground or surface water. • Deforestation for agricultural or urban development that damages or destroys terrestrial forest habitat, increasing siltation and altering hydrological regimes • contamination of ground or surface water • stochastic environmental events due to the small sizes of the populations • collecting • human recreation in or near salamander habitat	
Rescue Effect (immigration from an outside source)	
• *Status of outside population(s)?* **USA:** *Desmognathus ochrophaeus* in the United States has a large and continuous range and is considered common with no major threats. It is ranked as N5 in the U.S., indicating that the species is secure nationally. It is secure in 7 states including New York State.	
• *Is immigration known or possible?* The population is isolated by the large and fast flowing Niagara River and is 22 km from the closest US population.	No

• *Would immigrants be adapted to survive in Canada?* Populations in the U.S. are located in similar habitats and climates as those in Canada.	Yes, quite likely
• *Is there sufficient habitat for immigrants in Canada?* The range is very restricted and suitable habitats are already occupied by this species.	No
• *Is rescue from outside populations likely?*	No
Quantitative Analysis	NA
Current Status **COSEWIC: Endangered (2007)**	

Status and Reasons for Designation

Status: Endangered	**Alpha-numeric code**: D1

Reasons for Designation:

This is a small and secretive salamander, with aquatic larvae, that inhabits forested brooks, cascades, springs, or seeps where there is abundant cover in the form of crevices between stones, leaf litter, or logs. This species' entire range in the Carolinian faunal province consists of a single, cascading stream in the Niagara Gorge, occupying no more than about 0.005 km^2. The locality is isolated from any other population of the same species, the nearest being about 22 km away in New York State. Surveys to date have located and identified some 22 individuals and indicate a total adult population that is probably fewer than 100 individuals. Its minute range makes this salamander highly susceptible to stochastic events and the species would easily and rapidly become extirpated if any change to its habitat were to take place. The major threats to this salamander in Carolinian faunal province are any activities that could affect the water table and dry out the spring that supplies its habitat, degrade groundwater flow and quality or deplete groundwater reserves.

Applicability of Criteria

Criterion A: (Declining Total Population): Insufficient information.

Criterion B: (Small Distribution, and Decline or Fluctuation): The distribution in Canada is miniscule but there is insufficient information available to assess decline.

Criterion C: (Small Total Population Size and Decline): The number of individuals in Canada is likely under 100 adults but there is insufficient information available to assess decline.

Criterion D: (Very Small Population or Restricted Distribution): The species has population size of probably less than 100 individuals in a very restricted single location that is highly susceptible to any changes in water quality or quantity. The species thus is capable of being extirpated very rapidly.

Criterion E: (Quantitative Analysis): Not applicable.

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BIOGRAPHICAL SUMMARY OF REPORT WRITER

Tricia Markle obtained her Master's degree in biology at McGill University in 2006. Her thesis was an examination of phylogeography and range limitations of two species of stream salamanders (*Eurycea bislineata* and *Desmognathus fuscus)* in Quebec and Labrador. Before coming to Montreal she was an active member of the Victoria Chapter of the Society for Conservation Biology. She is currently a member of the Northern Dusky Salamander/Allegheny Mountain Dusky Salamander Recovery Team for Ontario, and has written several reports for the Ontario Ministry of Natural Resources on the Ontario population of the Allegheny Mountain Dusky Salamander.

COLLECTIONS EXAMINED

1. Canadian Museum of Nature, Ottawa, ON, voucher reference CMN # 31985 (*Desmognathus fuscus*)
2. Royal Ontario Museum, Toronto, ON, voucher reference ROM # 19813 (*Desmognathus ochrophaeus*)